Data Science in Action #3

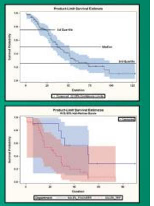
Getting More Insight into Your Forecast Errors using Multivariate Statistics

Gerhard Svolba
Data Scientist, SAS Austria

Data Science Applications and Case Studies

Data Science in Action: #1

Performing Headcount Survival Analysis for Employee Retention



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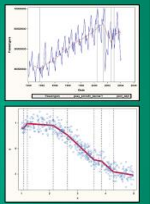
sas

Data Science in Action: #2

Detecting Structural Changes and Outliers in Longitudinal Data



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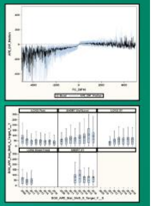

Do the demand planners really improve forecast accuracy with their manual overwrites?

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Linear Regression
Quantile Regression
Descriptive Statistics
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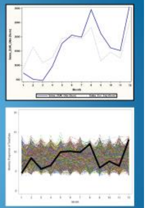
Checking the Alignment with Predefined Pattern



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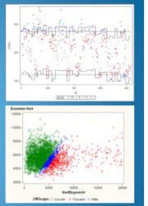

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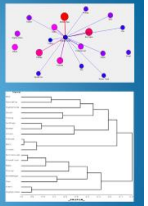

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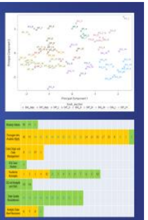

Can I automatically find clusters of documents with similar content?

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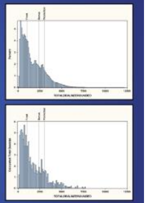

When the sales manager looks at the project pipeline, does the sum of weighted averages give him or her a full picture?

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Monte Carlo Simulations
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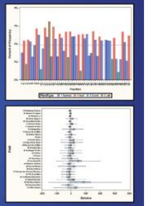
Studying Complex Systems – Simulating the Monopoly Board Game



How can you simulate complex environments to get insight in the most frequent processes?

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```

sas

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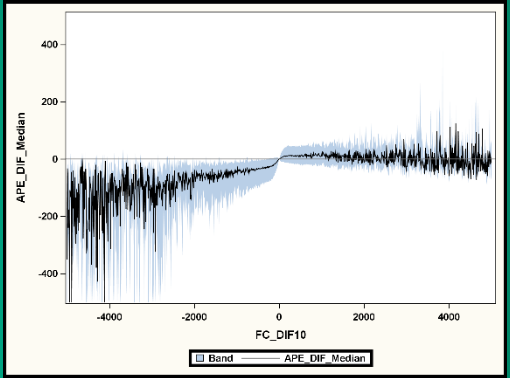
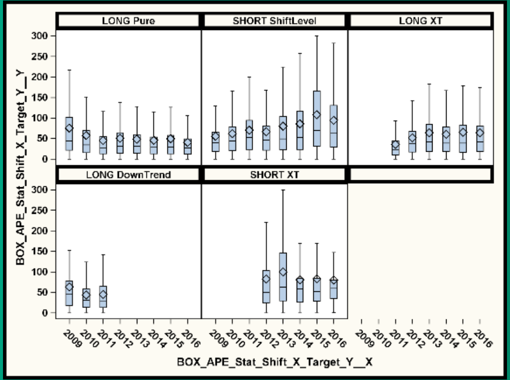
Explaining Forecast Errors and Deviations

Do the demand planners really improve forecast accuracy with their manual overwrites?



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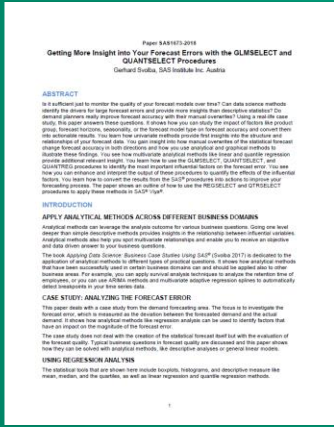

Paper SAS1673-2018
Getting More Insight into Your Forecast Errors with the GLMSELECT and QUANTSELECT Procedures
Gerhard Svolba, SAS Institute Inc. Austria
ABSTRACT
INTRODUCTION
APPLY ANALYTICAL METHODS ACROSS DIFFERENT BUSINESS DOMAINS
CASE STUDY: ANALYZING THE FORECAST ERROR
USING REGRESSION ANALYSIS


Displaying the Results Visually

SAS Global Forum
Paper SAS1673-2018

Getting More Insight into Your Forecast Errors with the GLMSELECT and QUANTSELECT Procedures

Gerhard Svolba, SAS Institute Inc. Austria

Denver, April 10th, 2018

This Presentation Provides You

Analytic Business Questions

Advanced Analytic Methods

Business Results and Actions

Data Preparation Considerations

6 Relevant Graph Examples

10 SAS Code Snippets

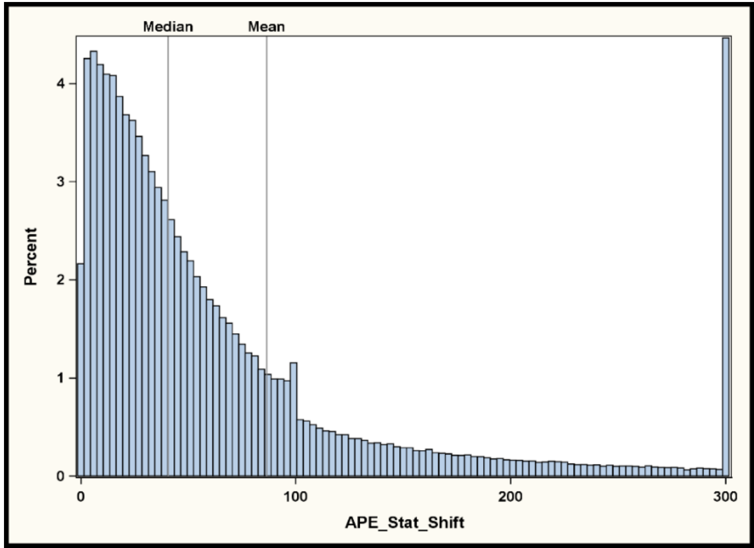
Regression Procedures in SAS Viya

Business Background of the Case Study

- International retail and manufacturing company
- Demand forecasts on a monthly basis
- Forecasts generated
  - Long history products (>15 months) → SAS® Visual Forecasting
  - Short history (fashion) products → SAS® VDMML
- Want to understand deviation in forecast quality

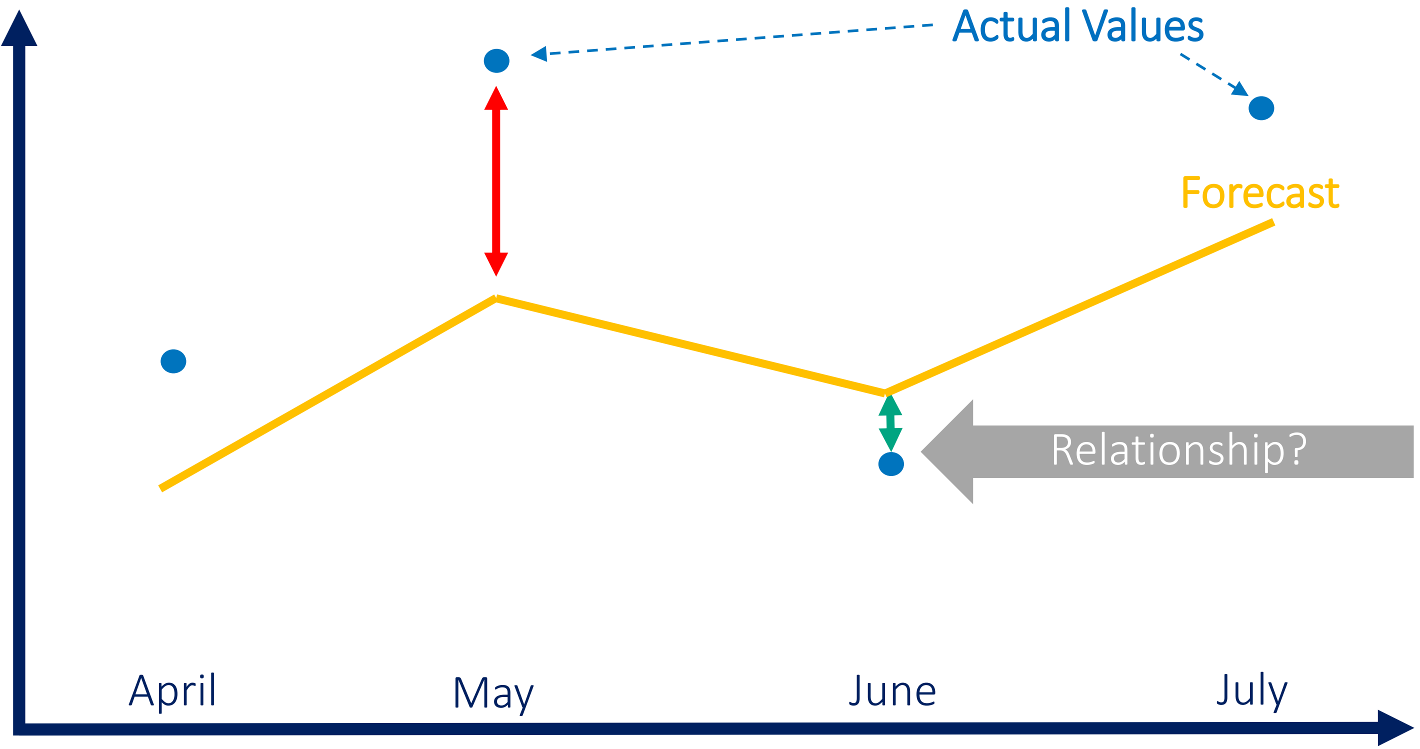
Business Questions for the Case Study

- What is the distribution of the forecast error?
- Which factors influence the forecast error?
- Where should you invest time to improve forecast quality?
- Which combinations might always have large forecast errors?
- Do manual overrides improve forecast quality?



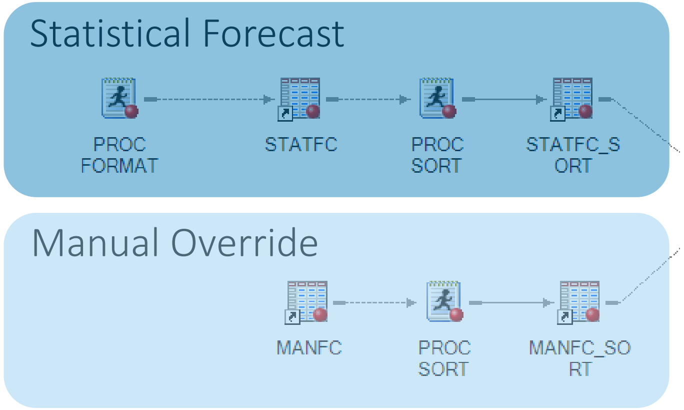
Basic Idea: Explain the „Size“ of the Forecast Errors

Forecast for Item 1673: „GPS Tracker Waterproof“



Product Group
Price
Launch Calendar Month
Product Age (=Data History)
Forecast Model
Lead Time
Target Year
Target Calendar Month

Available Data and Data Preparation



Forecast Model
Lead Time
Target Year
Target Calendar Month

Product Group
Price
Launch Calendar Month
Product Age (=Data History)

```
APE_STAT = abs(statfc - actual)/actual * 100
```

→ Absolute Percentage Error

Using the MAPE

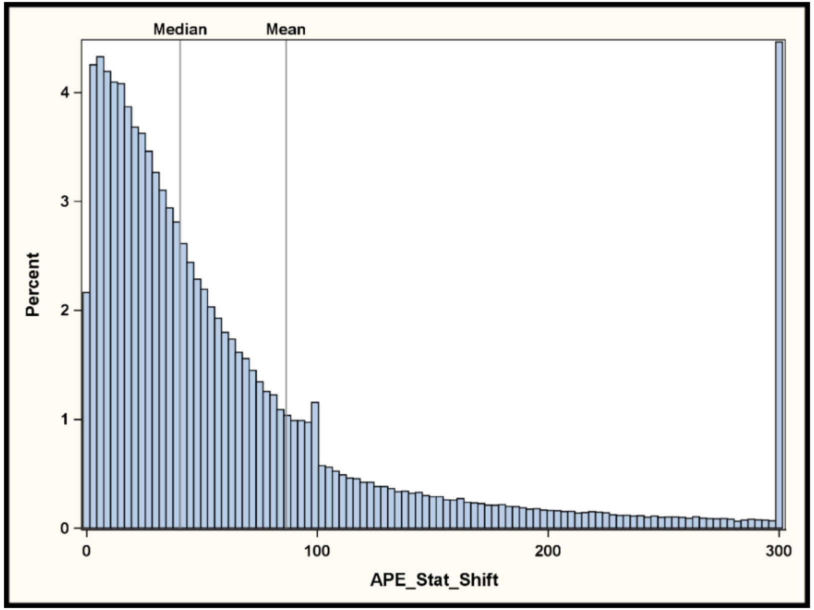
MAPE – Mean Absolute Percentage Error

- Why you might not use it:
  - MAPE is asymmetric; perfect fit results in a MAPE of 0.
  - If observed demand = 0 → MAPE formula: division by zero.
  - Forecast of 0 → MAPE=100. Forecasting might limit its forecast error by forecasting 0 for all time points.
- However:
  - INTERPRETABILITY!
  - Widely Used in Business Forecasting

Overall Distribution of the Forecast Error

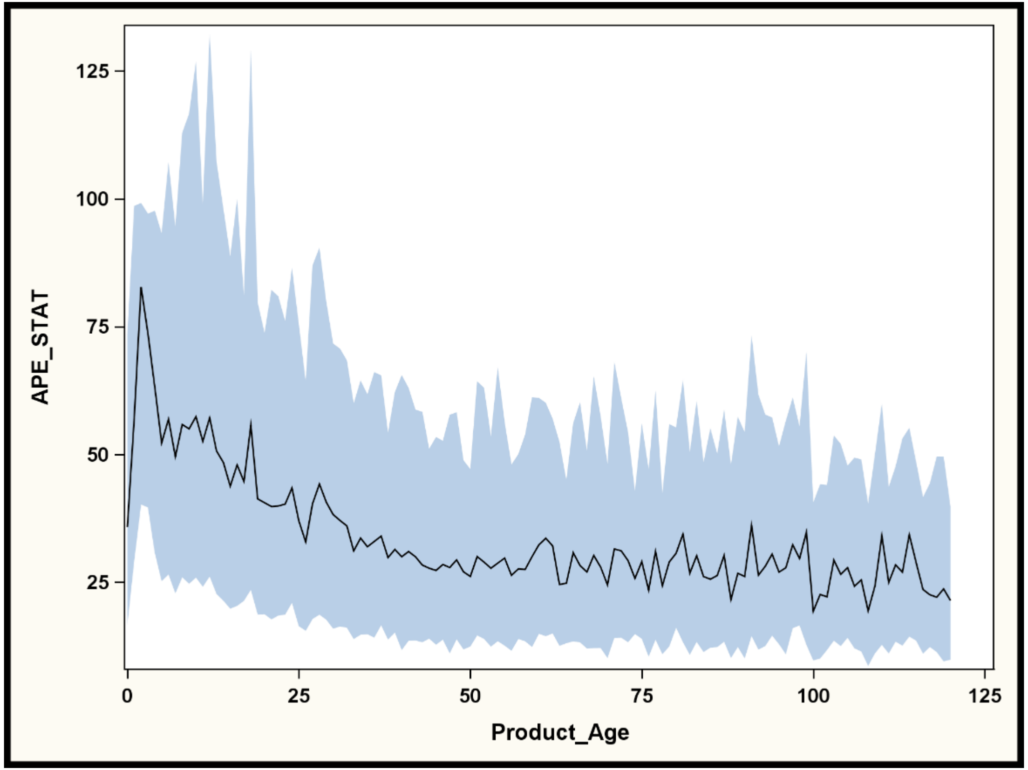
Mean of all APEs = 85.5

Quantile	Value
100% Max	238,954.6
95%	276.6
90%	169.5
75% Q3	81.7
50% Median	40.6
25% Q1	18.0
10%	7.0
0% Min	0



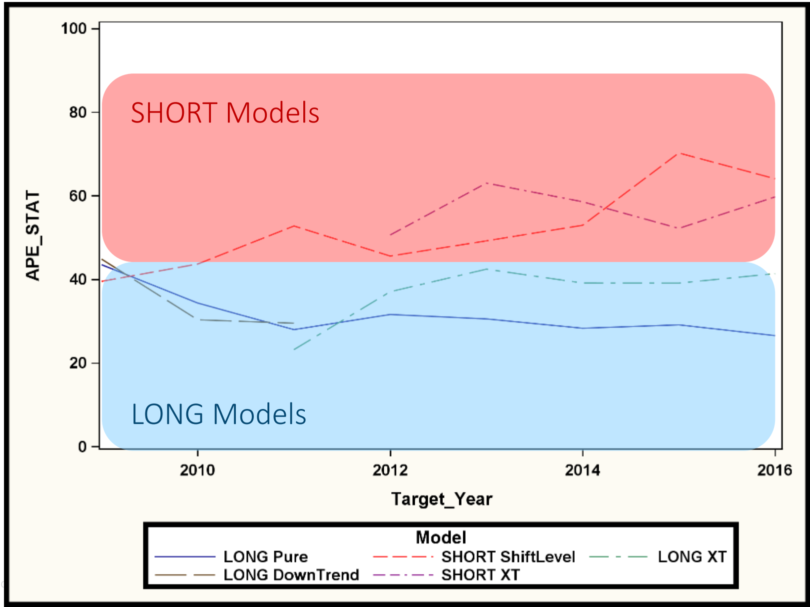
Using a Band (1st+3rd Quartile) and a Line (Median) Chart

→ Longer Data History reduces Forecast Error

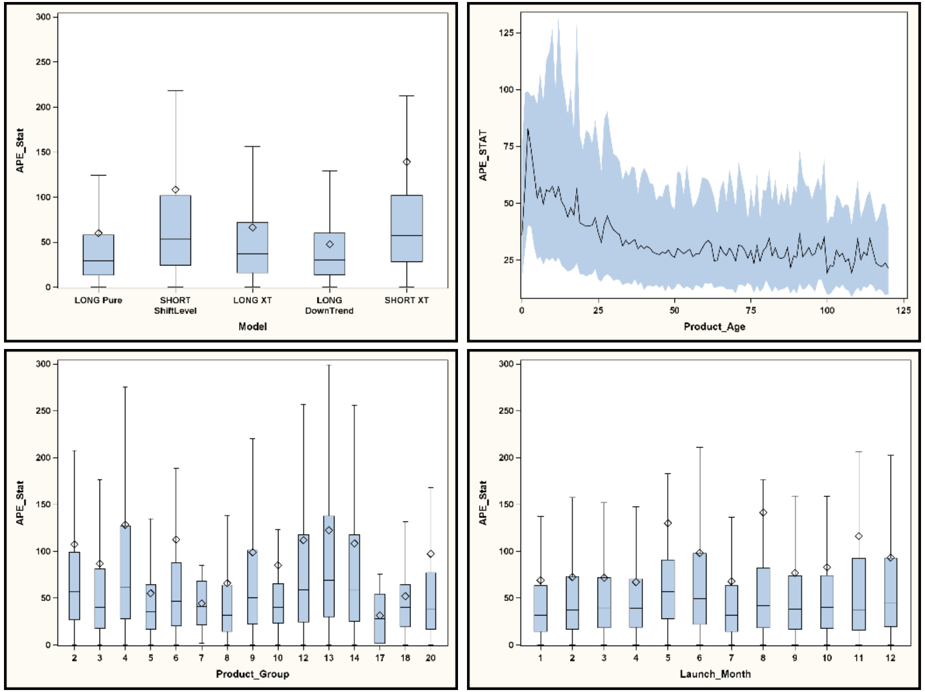


Also Descriptive Methods help!
Analyze the Forecast Error Over Time

- Forecast Errors for short-term products are higher (and increasing over the years)
- Some Forecast Models are discontinued and replaced by other Models
- Some models might exhibit a larger forecast error because they are used to forecast „special“ products



Results from Univariate Linear Regression Models



Rank	Input Variable	R-squared
1	MODEL	0.0554
2	PRODUCT_AGE	0.0433
3	PRODUCT_GROUP	0.0224
4	LAUNCH_MONTH	0.0172
5	TARGET_YEAR	0.0102
6	TARGET_CALMONTH	0.0084
7	LEAD_TIME	0.0046
8	PRICE_INDEX	0.0016

```
PROC GLMSELECT DATA=fc_mart;
 MODEL ape_stat_shift = product_Age;
RUN;
```

Comparing the Selection Order of Variables in the Univariate and the Multivariate Linear Regression Model

Rank	Input Variable	Adjusted R-square	Beta (Good/Bad)		Rank (Change)
1	MODEL	5.46%	Long	Short	1 (=)

Use the Regression Model to Calculate the expected MAPE for new Data

Model Logic from
PROC GLMSELECT
SCORE or STORE Statement

Product 1440 „SGF T-Shirt“
Product group: 10
Launch month: July
Target month: May 2015
Product age: 10 months old
Lead time: Four months
Forecats model: model SHORT_XT

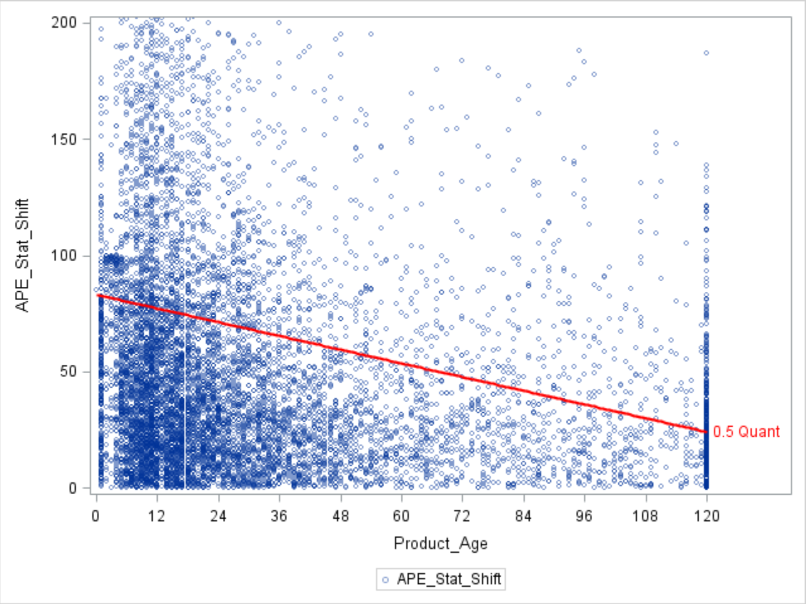
Scoring

Expected
MAPE = 65.1

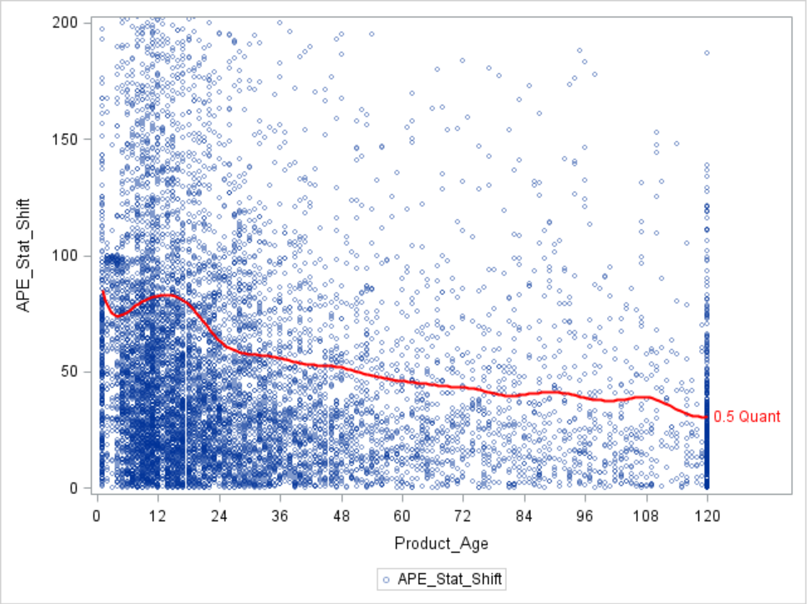
Studying Linear Regression Results Visually

Influence of Variable PRODUCT_AGE

Univariate Analysis (PRODUCT_AGE only)

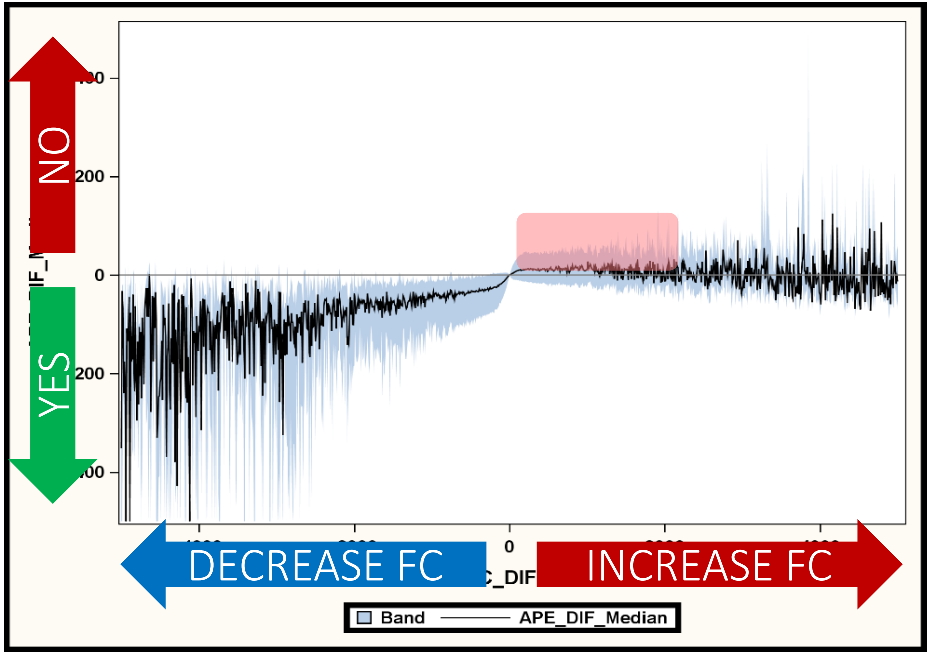


Multivariate Analysis (8 variables)



Do Demand Planners improve Forecast Quality with their Manual Overrides?

- Line and Band Chart:
  - The median is shown by a solid black line.
  - The first and third quartile are displayed by a band.
- Larger changes → Larger effect
- Corresponds with the work of Paul Goodwin (2009)
- Demand planners obviously put more thought into large changes ☺
- Eliminate the small changes in your process! (Usually do not add any benefit.)



Possible next Steps

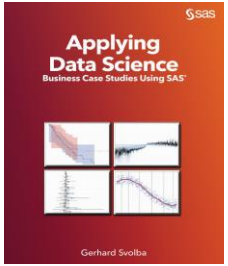
- Build a decision tree to discover segments with high/low forecast error
- Build a machine learning model that calibrates/suggests the optimal override
  - FVA (Forecast Value Add) Analysis
  - Also consider additional explanatory variables (product and forecast features)

Take-Aways from this Presentation

- **Application of analytical methods** provides relevant insights and help you make better business decisions.
- **Descriptive and visual methods** also provide a lot of insight to understand business relationships
- **Multivariate regression analysis** provides a more comprehensive picture than the isolated univariate analysis of influential factors.
- **Quantile regression** enables you get a clearer picture about the extremes of your distribution.
- The **SAS platform with SAS9 and SAS Viya** procedures provides a comprehensive set of analytical methods

Analytics and Data Science is there to help you!

- Get a clearer, more objective picture of your data and your analysis subjects
- Get explicit results instead of searching the needle in the haystack
- Make your data talk to you!
- Receive findings automatically instead of manually
- Do it again! – treat models as an asset and repeat your analysis



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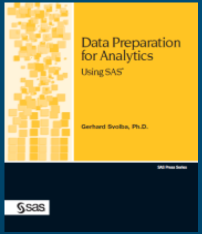

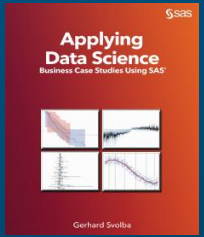

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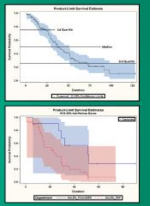

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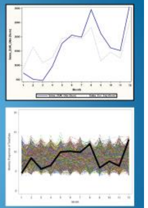

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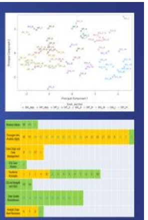

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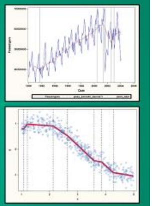

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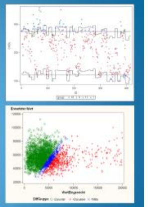

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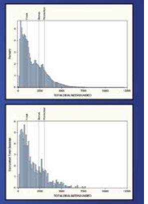

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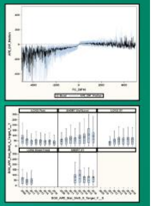

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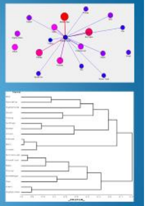

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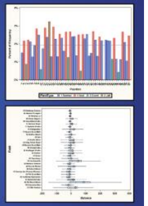

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